AMENDMENTS TO THE SPECIFICATION

Please replace the paragraphs beginning on page 1 and ending on page 10, with the following amended paragraphs:

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. patent application S[[s]]er. N[[n]]o. 09/653,314, filed on 1 Sept. 2000, now abandoned, and entitled "M[[m]]ethod for C[[c]]alibrating C[[c]]olor I[[i]]mage S[[s]]canners".

FIELD OF THE INVENTION

The present invention relates to a method for calibrating a color image scanner, and especially to a calibration method for keeping a constant color scanning quality of an image scanner.

BACKGROUND OF THE INVENTION

Since the properties of the sensors (not shown) are different, before being sold, the colors of each image scanning system (for example, scanners, color copiers, etc) must be calibrated for assuring the correction of colors in the image scanning system.

Referring to Fig. 1, a schematic view of a conventional image scanning system. In the figure, the image scanning system 40 has a scanner body 42, and a cover 44. The scanner body 42 has a scan window 46, a driving unit 48 and an optic mechanical module 60. The scan window 46 serves to receive documents to be scanned (not shown). The optic mechanical module 60 has a detection circuit

and a converting circuit (not shown) for scanning aforesaid document. The driving unit 48 serves to drive the optic mechanical module 60 so as to travel under the scan window 46. In the conventional color calibration procedure, a calibration chart 50 with standard white color is installed on the surface of the scan window 46 in the image scanning system 40. When a conventional ~~normal~~ image scanning system 40 scans, the respective signal of the calibration chart 50 with a standard white ~~while~~ color will be detected by the image scanning system 40 and it is determined whether this signal is within a standard range. Therefore, one can ~~it is~~ easily ~~to~~ adjust the correction of the colors from the image scanning system 40 and thus the parameters of the related circuit can be adjusted. However, in the image scanning system, since the calibration chart 50 is a standard white color slice, it can not be used to exactly calibrate the three primitive colors, red, green, and blue. To an ~~In some~~ extent, a standard white color is formed by linear combination of the vectors of the red, green and blue colors, so ~~and~~ the error in ~~for~~ each primitive color can't respond ~~be response~~ correctly. Namely, in the image scanning system, even when a color calibration process is performed accurately, the quality of the output color can still not be assured. Therefore, when the user finds some faults in scanning an image, a manual adjustment to calibrate the colors of an image scanning system is required. Not only the cost is increased, but also the quality can not be well controlled.

SUMMARY OF THE INVENTION

Accordingly, the primary object of the present invention is to provide a method for calibrating a color image scanner. Thereby, the defect from the manual adjustment in the prior art is removed. In the present invention, a color~~ful~~

calibration chart is installed on the surface of the scan window of a color image scanner. Then, according to the sensed signal of the calibration chart, a ~~the~~ parameter, e.g. gain, of a converting circuit of an optic mechanical module is adjusted with a feedback loop so that the quality of the output color from the image scanning system can be retained at ~~in~~ a predetermined level.

Another object of the present invention is to provide a method for calibrating a color image scanner, the defect from the manual adjustment in the prior art is removed. The color of the image scanner can be calibrated automatically so as to improve the quality of the output image. And thus, it is performed without increasing cost, and is economical.

For reaching the objectives above, the present invention proposes a method for calibrating a color image scanner. A color~~ful~~ calibration chart is installed on the surface of the scan window of a color image scanner. Then, according to the sensed signal of the calibration chart, a ~~the~~ parameter, e.g. gain, of a converting circuit of an optic mechanical module is adjusted with a feedback loop so that the quality of the output color from the image scanning system can be retained at ~~in~~ a predetermined level. Therefore, the defect from the manual adjustment in the prior art is removed and it is performed without increasing cost, and is economical.

The various objects and advantages of the present invention will be more readily understood from the following detailed description when reading in conjunction with the appended drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of a conventional image scanning system.

Fig. 2 is a schematic view of an image scanning system according to the present invention.

Figs. 2a~c are schematic diagrams of calibration charts according to the present invention.

Fig. 3 is a detailed operative flow of a preferred embodiment of the method for calibrating the color image scanning system in compliance ~~complied~~ with the present invention.

Fig. 4 is an operative flowchart for adjusting gain in the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to Fig. 2, a color image scanning system of the present invention is illustrated herein. The color image scanning system 1 is formed by a scanner body 2 and an upper cover 3. The scanner body 2 has a scan window 10, a driving unit 12 and an optic mechanical module 14. The scan window 10 serves to receive documents to be scanned (not shown). The optic mechanical module 14 includes imag~~ine~~ sensors and a converting circuit (for example, analog / digital converter) for detecting the document to be scanned and converting the sensed signal into a digital signal. The driving unit 12 serves to drive the optic mechanical module 14 so as to be traveled under the scan window 10.

The present invention is different from the conventional calibration method. In the present invention, a color~~ful~~ calibration chart 16 is placed on the surface of the scan window 10, and then the sensed signal of the calibration chart 16 is used to calibrate the parameter of the converting circuit.

Please refer to Figs. ~~fig.~~ 2a~c. There are three ~~tree~~ embodiments of the calibration chart 16. In fig. 2a, the calibration chart 16 has three primitive color regions 162,163 and 164, whose colors are red (R), green (G) and blue (B), respectively. These three colors need ~~are~~ not ~~necessary to~~ be pure colors, i.e. not necessary to be saturated colors. Further, the calibration chart 16 has a white region 161, which is used for shading as well known in the prior art.

The embodiment in fig. 2b is similar to that in fig. 2a. The only difference is that the colors of the three primitive color regions 162', 163' and 164' are cyan (C), magenta (M) and yellow (Y).

The embodiment in fig. 2c is also similar to that in fig. 2a. The only difference is that the calibration chart 16 only has a primitive color region 165, whose color is a non-saturated color or gray.

Please refer to fig. 3, which is a detailed operative flow of a preferred embodiment of the method for calibrating the color image scanning system in compliance ~~complied~~ with the present invention. As an example, this embodiment employs the calibration chart 16 with the primitive colors of red (R), green (G) and blue (B) shown in fig. 2A . The method includes following steps:

Step 103: scanning the white region of the calibration chart 16.

Step 105: reading data by using the image sensors on the circuit board of the optic mechanical module 14.

Step 107: converting data to R.G.B. value by using analog-to-digital converters (A/D converter).

Step 109: amplifying the maximum value in each pixel to 250~255 (the maximum region), wherein each pixel is represented by 8 bits in this embodiment.

Step 111: adjusting gain.

Step 113: scanning a color region of the calibration chart 16.

Step 115: reading data.

Step 117: converting data to R.G.B. value.

Step 119: summing the R.G.B. values respectively converted from the data read from the white region and the color region of the calibration chart 16, and further averaging the R.G.B. values thereof.

Step 121: calculating an averaged compensating value for scanning as described in more detail below.

Step 123: then the color image scanning system processes scanning and compensating the scanned image referring to the summed R.G.B. value and averaged R.G.B. value.

Please refer to fig. 4, which is an operative flowchart for adjusting gain in the present invention. In step 111, assume a sensed value of a pixel is v and the current gain is g, then the gain adjustment value ~~adjusted volume~~ is d. Therein, the value of d can be modified according to different situations. The step 111 includes the following steps:

Step 21: checking if the current pixel value exceeds the maximum value. If it exceeds ~~positive~~, perform step 22. Otherwise, perform step 23.

Step 22: g=g-d.

Step 23: g=g+d.

Step 24: checking if the sensed pixel value v is in the maximum region. If v is in the maximum region ~~positive~~, jump to step 26. Otherwise, perform step 25.

Step 25: adjusting the value d according to the difference between the maximum value and value v. If the difference is large, magnify the value d. Otherwise, minify the value d. Then, jump back to step 21.

Step 26: gain adjusting process is completed.

In the step 121 described above, the image sensors of the optic mechanical module 14 not only can respectively sense a unique color such as R, G or B, but also can sense a little optical power of other colors. This is due to the ~~That results from~~ properties of the filter lens or the light source. Hence, the sensed ~~sensing~~ values are still influenced by other optical spectrums. For example, if an image sensor is used for sensing red, it not only can sense the optical power of red, but also can sense a little optical power of blue or green. Consequently, if the sensed ~~sensing~~ value is (R, G, B) and the real value is (r, g, b), their relation can be expressed as:

$$R=a_{11}*r+a_{12}*g+a_{13}*b+c_1 \text{----------} (1)$$

$$G=a_{21}*r+a_{22}*g+a_{23}*b+c_2 \text{----------} (2)$$

$$B=a_{31}*r+a_{32}*g+a_{33}*b+c_3 \text{----------} (3)$$

Therein, a_{ij} (i, $j=1, 2, 3$) are relative coefficients between the sensed colors and real colors, and c_1, c_2, c_3 are the minimum values that can be sensed (these values correspond to when the real color is ~~are the sensing values of~~ black ~~color~~).

The equations (1)~(3) can be expressed by matrices as following:

$$(R、G、B)^T=A(r、g、b)^T+C \text{----------} (4)$$

wherein matrices A and C can be written as:

$$A=\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \qquad C=\begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

Since the real colors in the calibration chart 16 are known, we can use the sensed colors and real colors to obtain the matrices A and C.

Moreover, due to the obtained transfer function (4), we can get the correct colors in the step 123 by using the scanned image and the following inverse ~~reverse~~ function:

$$(r、g、b)^T=A^{-1}((R、G、B)^T-C)$$

Thereby, the correct colorful image can be obtained.

In summary, the method for calibrating a color image scanner according to the present invention has the following advantages:

1) The defect from the manual adjustment in the prior art is removed.

2) The colors of the image scanner can be calibrated automatically so as to improve the quality of the output image.

3) The method of the present invention is performed without increasing cost, and is economical.

Although the present invention has been described with reference to the preferred embodiments, it will be understood that the invention is not limited to the details described thereof. Various substitutions and modifications have been suggested in the foregoing description, and others will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intended to be embraced within the scope of the invention as defined in the appended claims.

Please replace the paragraph (ABSTRACT) beginning on page 14, with the following amended paragraph:

A method for calibrating a color image scanner is disclosed. A colorful calibration chart is installed on the surface of the scan window of a color image scanner. Then, according to the sensed signal of the calibration chart, the parameter of a converting circuit of an optic mechanical module is adjusted with a feedback loop so that the quality of the output color from the image scanning system can be retained at ~~in~~ a predetermined level. Therefore, the defect from the manual adjustment in the prior art is removed and it is performed without increasing cost, and is economical.

REMARKS/ARGUMENTS

This case has been carefully reviewed and analyzed in view of the Office Action dated 10 December 2007. Responsive to the rejections and objections made in the Official Action, a Substitute Specification is being provided herewith. No new matter has been added to the Substitute Specification. In addition, Claims 1, 2, 3, 6 and 8 have been amended; Claim 5 has been canceled.

The Examiner objected to both the Disclosure and Abstract of the Specification, citing numerous grammatical and idiomatic errors. Thus, the Disclosure and Abstract have been amended to obviate the Examiner's objections. Also, the Examiner objected to portions of Claims 1, 2, 5, 6 and 8, also for various grammatical and idiomatic errors. The Claims have been amended to obviate those objections.

The Examiner rejected Claims 1-4 and 6-8 under 35 U.S.C. § 103(a) as being unpatentable over Bushaw, et al., U.S. Patent 4,408,231 in view of Houston, et al., U.S. Patent 6,442,497. The Examiner also rejected Claim 5 as being unpatentable over Bushaw, et al. and Houston, et al. in view of Ishima, U.S. Patent 5,101,281.

Prior to discussing the rejections made by the Examiner, it is believed beneficial to first briefly describe the subject Patent Application in light of the amended Claims. The subject Patent Application is directed to a method for <u>automatically</u> calibrating a color image scanner. Among its steps, the method includes scanning a white region of a <u>color</u> calibration chart (103) and converting the scanned data to <u>digital</u> red/green/blue (RGB) values; then amplifying a maximum value of each pixel (109) to a predetermined region. The step of gain

adjustment (111) then occurs by checking to see if a current pixel value exceeds the maximum value (21). If it does, the adjusted value is subtracted from the current gain value (22); if not, the adjusted value is added to the current gain value. The sensed pixel value is then checked to see if it is within the predetermined region (24) and finally the gain value is adjusted (25) according to the <u>difference between the maximum value and the sensed pixel value</u>.

The method continues next by scanning a <u>color region</u> (113) of the color calibration chart and converting that data to digital RGB values. Those values are then summed with the first set of RGB values scanned from the white region of the color calibration chart and averaged (119). The method concludes by utilizing the summed and averaged RGB values to scan and compensate the image relative to the adjusted summed and averaged RGB values. The step of calculating the average compensating value (121) includes a matrix transformation, transforming the sensed RGB values into real (rgb) values and inclusion of minimum values (real black color values).

The Examiner cited Bushaw, et al. in view of Houston, et al. in rejecting Claims 1-4 and 6-8. The Bushaw, et al. invention pertains to a linear image sensor and the video channel associated with the sensor, which is calibrated to maximize the video signal available. The Examiner stated that Bushaw, et al. teaches the elements recited in the subject Application except for scanning a color region of the calibration chart; reading second data; converting the second data to second RGB values; summing and averaging; and calculating averaged compensating value for scanning. The Examiner stated that Bushaw, et al. teaches a method that includes scanning a white region of a calibration chart, and for this proposition cited column 2, lines 63-66, which states that "The calibration of the lamp 10 and

the variable gain amplifier 12 takes place while the CCD linear image sensor 18 is sensing reflected light from a white reference strip 20." However, this citation clearly teaches away from the subject Application since what is being calibrated in Bushaw, et al. is the lamp or light source and not the image sensor. Further, evidence of such teaching away is seen in "... the invention relates to calibrating the light illumination used with the scanning array ..." (emphasis added, column 1, lines 9-10). Moreover, the lamp intensity is regulated relative to the signal saturation level of the CCD in linear image sensor 18 (column 3, lines 48-49). Additionally, "... the microprocessor controls the intensity of lamp 10 to bring the image sensor 18 to the saturation point ..." (column 6, lines 13-15). Clearly, and as pointed out in the very passage cited by the Examiner, the Bushaw, et al. invention calibrates the light source in conjunction with an adjustment to the amplifier gain; and does not calibrate by itself the image sensing device/CCD.

More importantly, however, Bushaw, et al. clearly indicates that the calibration procedure is performed "... before the analog signal is digitized or otherwise processed ..." (column 1, lines 6-7). This is in contradistinction to the subject Application in which the scanning of the white region of the calibration chart and reading of data occurs first, immediately followed by conversion to digital RGB values via an analog-to-digital converter (ADC), followed by amplification of the maximum value of each pixel to a predetermined region and adjustment of gain. This is an important distinction, for the entire scanning and calibration process of Bushaw, et al. is based on calibrating the light source. The subject Application does not need to calibrate the light source and thus the early conversion to digital RGB values ensures a much more simplified and automatic calibration procedure.

The Bushaw, et al. invention relies on complicated analog-to-digital and digital-to-analog conversion, in conjunction with adjustment of the gain amplifier. Also, the illumination applied to the photosensor array of Bushaw, et al. must be adjusted for maximum video signal range (column 2, lines 19-22). The gain must be set to produce a white signal level that is a predetermined percentage of the maximum swing available in the analog-to-digital converter in the video channel (column 2, lines 23-26). The gain of the subject Application does not require and is not based on any predetermined values of any sort.

The need of the Bushaw, et al. invention to link the gain of the white level signal to the saturation point of the array and the maximum video signal level available is due to the fact that Bushaw, et al. does not include a color portion of the calibration strip; it is only scanning a white portion, hence the need to determine a maximum signal level available with respect to white peak signal levels.

The gain adjustment feature cited by the Examiner relies on an incremental adjustment of the variable gain amplifier until the converted analog-to-digital value reaches the 100% range of the analog-to-digital converter (column 6, lines 15-18). The microprocessor then tracks the gain of the amplifier by storing a software gain DAC value. Thus the gain adjustment of Bushaw, et al. relies on an incrementing procedure and also a necessary conversion back from digital-to-analog in order to adjust the lamp or light source. No such incrementing and back converting is required in the subject Application. The gain adjustment of the subject Application is simplified and is evidenced by reference to Fig. 3, steps 107, 109, and 111. Since the scanned data are immediately converted to RGB (digital) values, the subsequent amplification of the pixels to a maximum value between

250-255 makes it easy to adjust the gain. The gain adjustment is illustrated in Fig. 4 of the subject Application: the current pixel value sensed is compared to the maximum set value. It is either incremented or decremented in order to adjust the gain. The resulting adjustment is checked for compliance within the maximum region and finally the adjusted value is set according to the difference between the maximum value and the sensed value. In other words, the early digitization of the scanned data makes the subsequent amplification and gain adjustment a direct process. No digital-to-analog conversion is required.

The Examiner stated that Bushaw, et al. did not specifically teach the first data being RGB data and that the CCD is a single channel linear array sensor. The Examiner then noted that it would have been obvious to one of ordinary skill in the art to adjust the variable gain amplifiers of the CCD containing three linear arrays in a similar manner as taught by Bushaw, et al. However, it would not be obvious because the Bushaw, et al. device scans only a white region and the complicated calibration procedure is necessary; further, this calibration procedure as already discussed above relates to calibration of the light source in conjunction with the variable gain amplifier and does not simply calibrate the image sensor in and of itself.

The Examiner combined the Bushaw, et al. reference with Houston, et al. Specifically, the Examiner cited Houston, et al. for teaching the steps of scanning a color region of the calibration chart, reading second data, summing and averaging, and calculating averaged compensating value for scanning. Regarding the last element, the Examiner cited Houston, et al. for teaching the scanner calibration matrix M (column 3, lines 45-47); and stated that it would have been obvious to combine Bushaw, et al.'s initial step of calibrating the CCD sensor with

Houston, et al.'s subsequent step of generating a calibration matrix that corrects the color values sensed by the scanner. Houston, et al.'s invention is directed to a method of calibrating a scanner in a digital photofinishing system; the steps including providing a calibration strip having a series of calibration patches including a plurality of neutral and colored patches. It is respectfully believed that it is in no way obvious that Houston, et al.'s calibration matrix combined with Bushaw, et al. would have been obvious to one skilled in the art. Houston, et al.'s teaching pertains to calculation and calibration of a D_{min} calibration strip, which is a portion of unexposed film. Moreover, the matrix disclosed in the Houston reference <u>does not teach, discuss, or include consideration</u> of minimum sensed quantities, such as real black color. The subject Application's matrix clearly specifies a relationship between real color values and sensed color values, and further includes the critical step of accounting for real black color as indicated in equations 1-4 (variable "c").

The Examiner cited Bushaw, et al. regarding the step of having another amplifier 26 restoring the DC level of the video signal to a predetermined level, in order to maximize the available maximum range of the analog-to-digital converter and the Examiner further stated that the zero level corresponds to the minimum sensed value. Bushaw, et al. uses the DC restore function because he is not digitizing the sensed values initially. The subject Application, however, immediately digitizes the sensed values and thus it is not necessary to include a DC restore function on the analog signal. Furthermore, this allows for the inclusion of minimum sensed values C_1, C_2, C_3, which pertain to real sensed black color – no such ability is included in the Bushaw, et al. invention. Again, the DC restore function is related to the overall methodology of Bushaw, et al. in

calibrating the lamp, and not the image sensor by itself. In sum, the difference between the subject Application and the Bush invention may informally be described as "Bush adjusts the lamp to the amp; the subject Application adjusts the amp to the lamp" (indirectly since the adjustment is with respect to the white regions reflecting light from the light source!).

With regard to Claim 5, the Examiner, noting the deficiencies in Bushaw, et al., combined Bushaw, et al. and Houston, et al. with the Ishima reference. The Examiner noted that Bushaw, et al. did not teach the step of gain adjustment using the difference between the maximum value and the sensed pixel value. The Examiner then cited Ishima for teaching the difference between the reference signal V_0 and the output signal voltage V_1 of the detect/hold circuit 2 (column 1, lines 51-57). Again, as noted with respect to the inventions of Bushaw, et al. and Houston, et al., Ishima's functionality is in the analog realm, not the digital realm. The scanned data of the subject Application is immediately digitized, all further amplification and gain adjustments are conducted in the digital realm. The detect and hold circuitry of Ishima is more susceptible to transient signals because no digitization takes place initially. Thus, any amplification of errors and/or transient signals will lead to further errors once those signals are digitized; the subject Application suffers from no similar shortcomings.

None of the references in combination provides for calibration independent of the light source and thus does not provide for "...said calibration of said color image scanner is independent of a light source..." as defined in now amended Claim 1. Additionally, none of the references in combination provides for "adjusting gain..." where the step of adjusting gain includes the combined steps of "...determining if a current pixel value exceeds the maximum value...subtracting

an adjusted value...adding the adjusted value...determining if the sensed pixel is in the predetermined region, and adjusting the gain value..."

Since none of the references, alone or in combination, teach and disclose the unique combination of features of the subject Patent Application, it is believed that those references, cannot make obvious the invention of the subject Application.

It is believed that the dependent Claims provide further patentable distinction, but are at least patentably distinct for the same reasons as the Claims upon which they respectively depend.

For all of the foregoing reasons, it is now believed that the subject Patent Application has been placed in condition for allowance and such action is respectfully requested.

No fees are believed to be due with this Amendment. If there are any charges associated with this filing, the Honorable Commissioner for Patents is hereby authorized to charge Deposit Account #18-2011 for such charges.

Respectfully submitted,
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